JÜLICH
FORSCHUNGSZENTRUM

Assessing hydrogen production from wind and solar power with an LCA

15.06.2016

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Agenda

Introduction

System definition

Environmental assessment

Conclusions

Introduction

Hydrogen in Germany for mobility mainly from wind energy

Source: Fotolia© DeVIce

Problems: - Limited area

- Social acceptance

Alternative: Import of renewable produced hydrogen, e. g. from solar power

→ High temperature hydrogen production processes

→ Long distance hydrogen transport

Comparison of solar hydrogen production incl. long distance transport with onsite wind hydrogen production

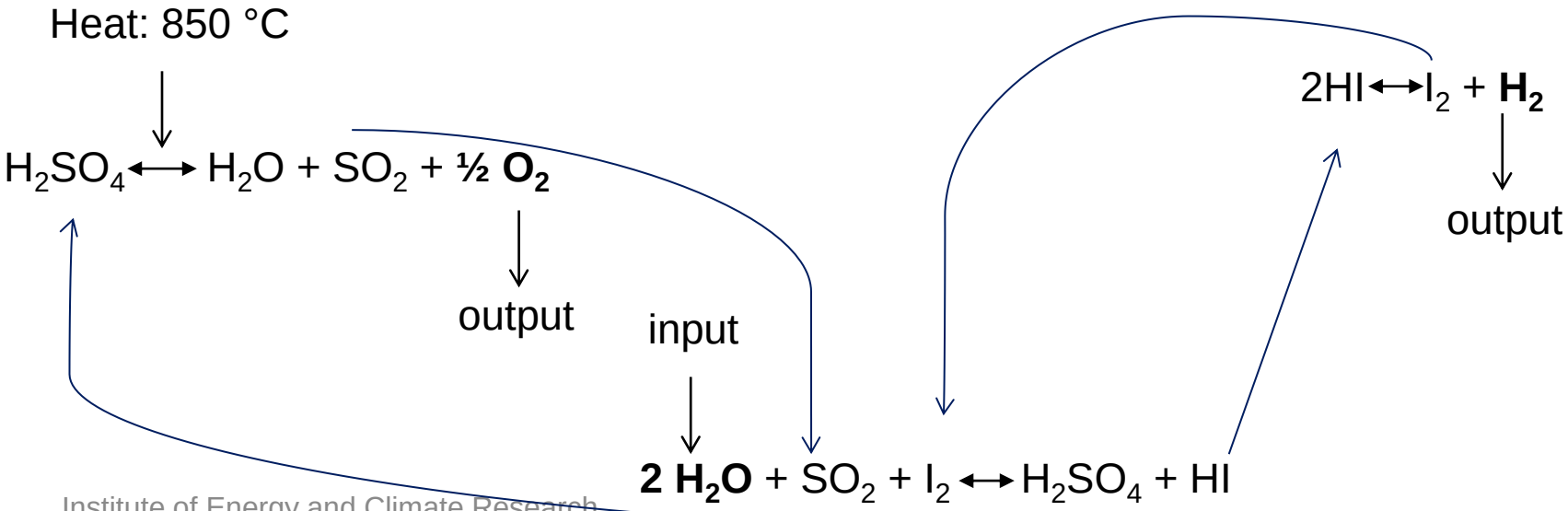
Source: Kosa1983

High-temperature hydrogen production

High-temperature electrolysis

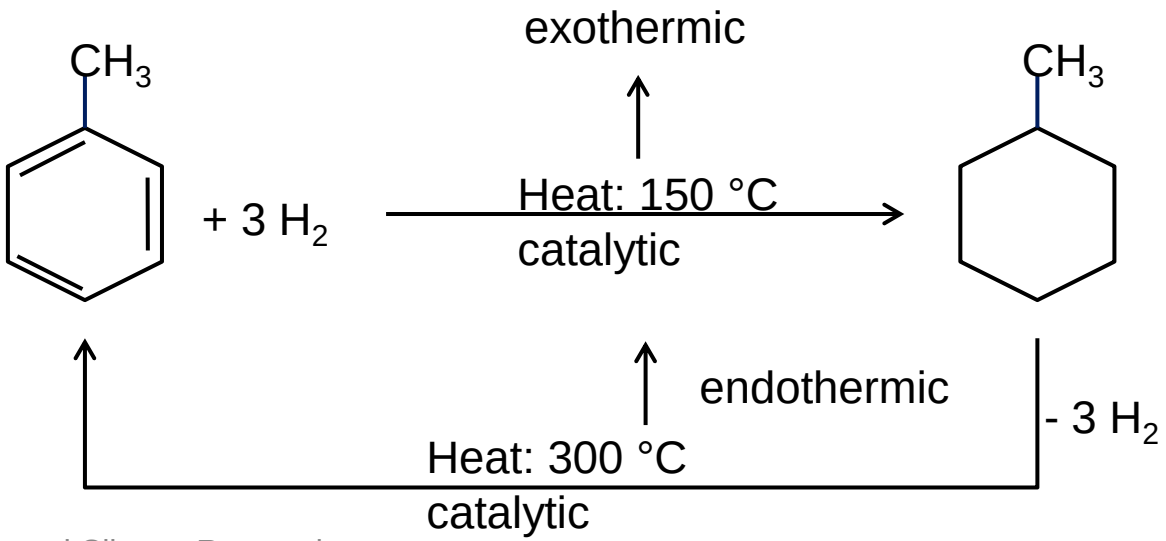
Thermochemical cycles

- Direct water splitting requires very high temperatures (2500 °C)
- Water splitting integrated into a chain of chemical reactions lowers the temperature to a manageable magnitude
- Sulfur–iodine cycle

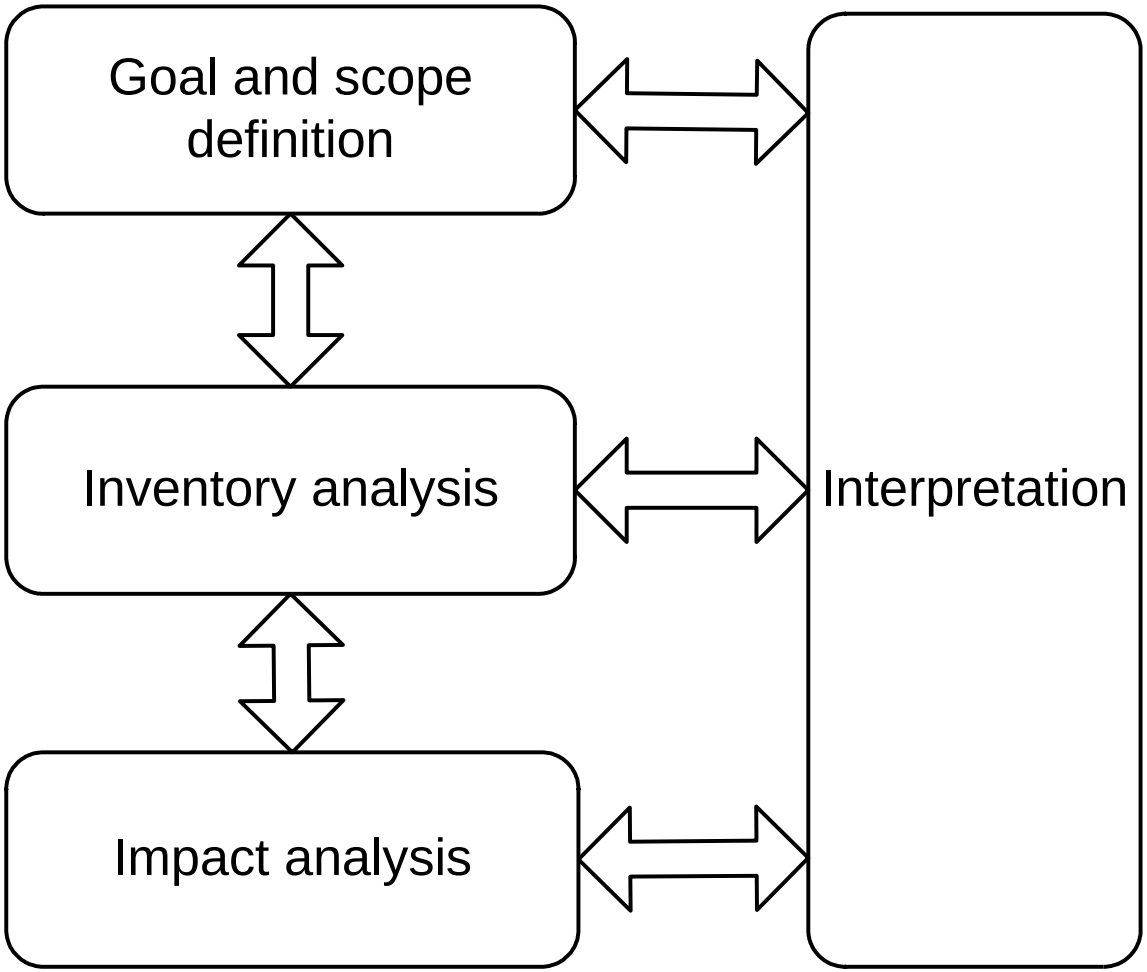


Long distance distribution: Liquid Organic Hydrogen Carriers

- Chemical compounds that bind hydrogen
- Up to 6.2 wt% stored hydrogen in LOHC possible
- Liquid can be handled like mineral oil products
- Possible compounds: e. g. dibenzyltoluene or toluene/ methylcyclohexane



LCA Methodology



Source: DIN 14040

Goal and Scope

Provision of 1 kg hydrogen at 700 bar for mobility applications at a hydrogen refueling station in Germany

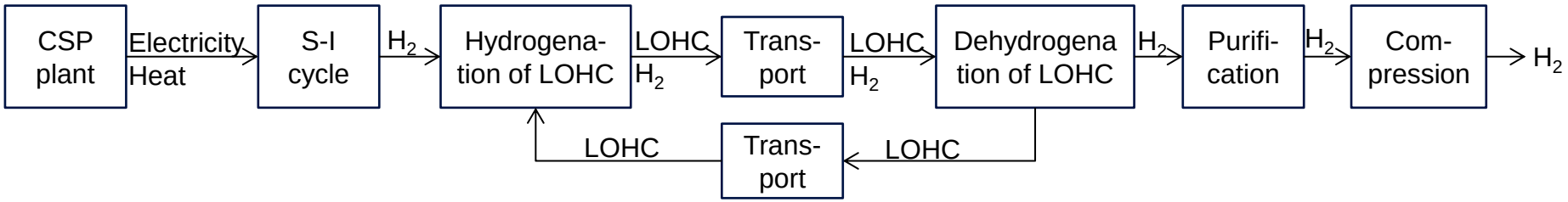
Solar hydrogen production in North Africa compared with wind hydrogen production in Germany

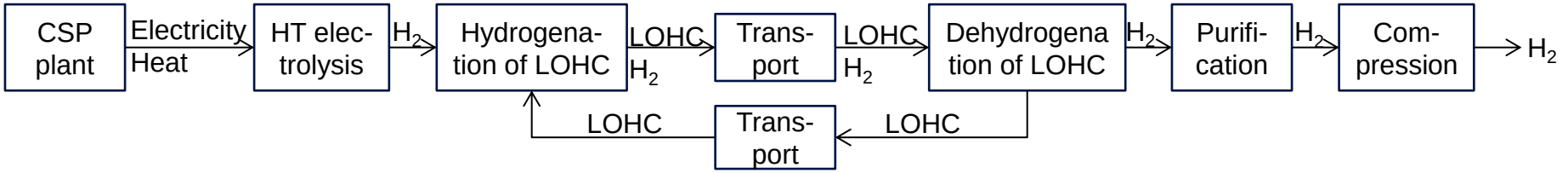
State of the technology of 2030

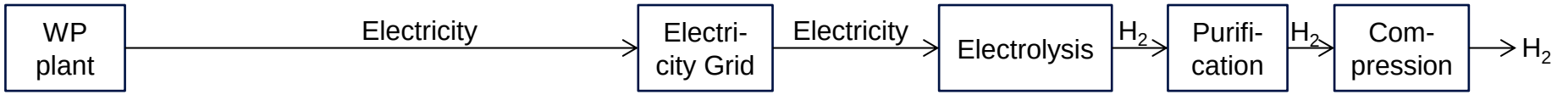
Analysis of impact categories:

- Climate change
- Acidification
- Eutrophication
- Photochemical ozone creation

System Definition







Important Parameters

High-temperature electrolysis:

- Production capacity: 208 kg H_2/h
- Heat at 850 °C: 2,5 kWh/kg H_2
- Electricity: 36 kWh/kg H_2

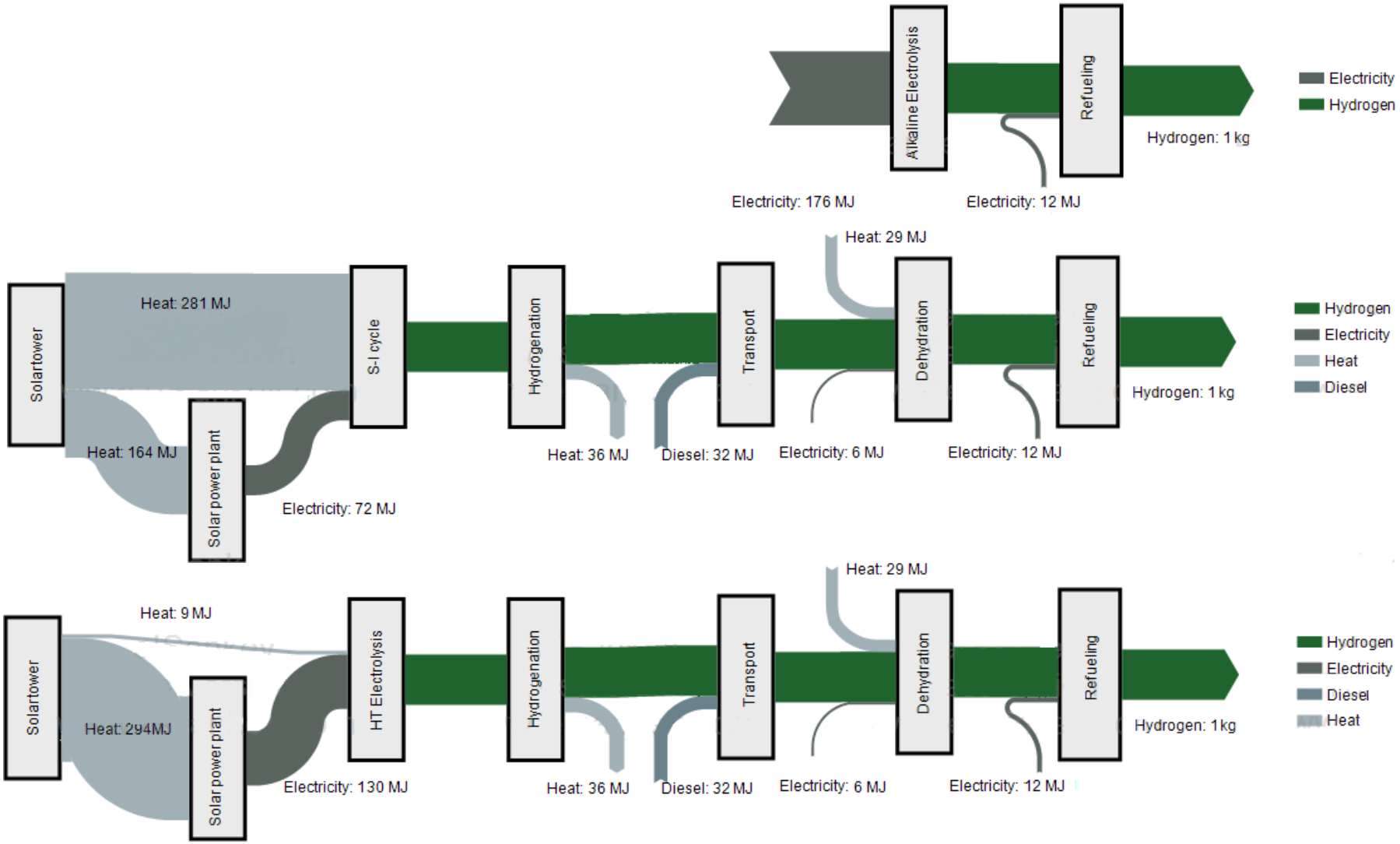
Sulfur-Iodine cycle:

- Production capacity 417 kg H_2/h
- Heat at 850 °C: 78 kWh/kg H_2
- Electricity: 20 kWh/kg H_2

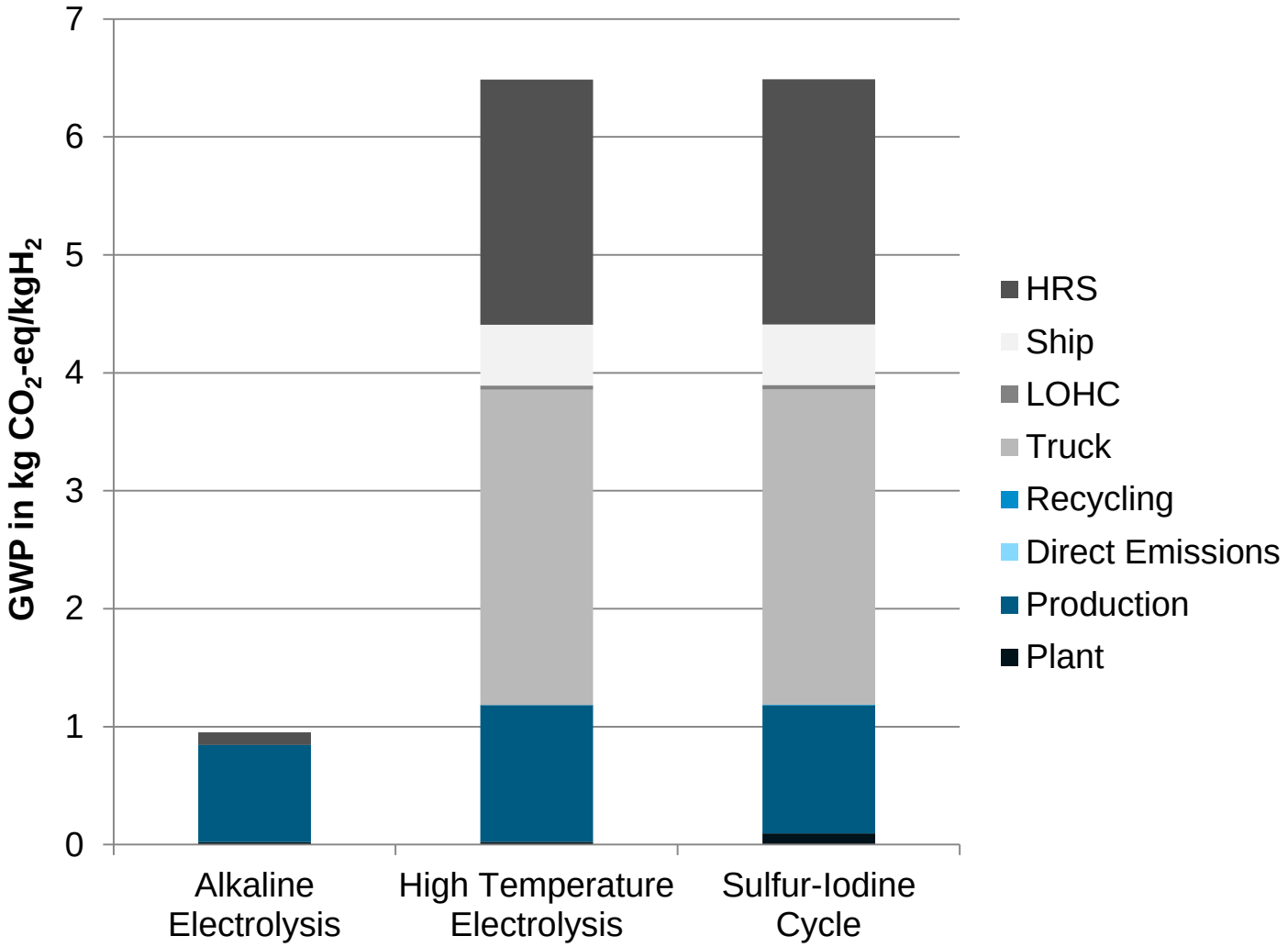
Alkaline water electrolysis:

- Production capacity: 4.4 kg H_2/h
- Electricity: 49 kWh/kg H_2

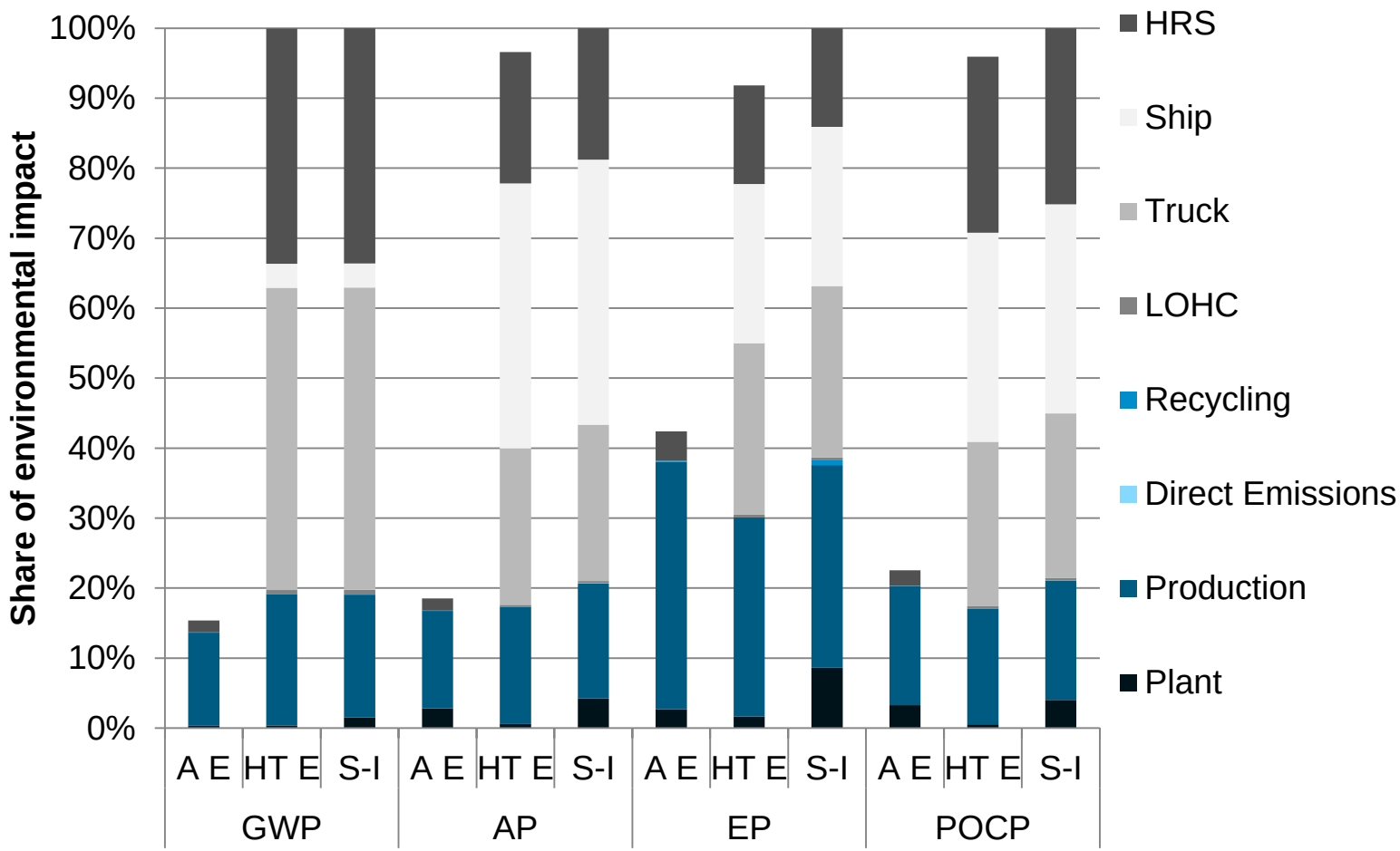
Efficiency


Alkaline Electrolysis
Refueling
Electricity
Hydrogen
Hydrogen: 1 kg
Electricity: 176 MJ
Electricity: 12 MJ
Solartower
Heat: 281 MJ
S-I cycle
Hydrogenation
Transport
Heat: 29 MJ
Dehydration
Refueling
Hydrogen
Electricity
Heat
Diesel
Hydrogen: 1 kg
Heat: 164 MJ
Solar power plant
Electricity: 72 MJ
Heat: 36 MJ
Diesel: 32 MJ
Electricity: 6 MJ
Electricity: 12 MJ
Heat: 9 MJ
Solartower
Heat: 294MJ
Solar power plant
HT Electrolysis
Electricity: 130 MJ
Hydrogenation
Transport
Heat: 29 MJ
Dehydration
Refueling
Hydrogen
Electricity
Diesel
Heat
Hydrogen: 1 kg
Heat: 36 MJ
Diesel: 32 MJ
Electricity: 6 MJ
Electricity: 12 MJ

LCA results climate change



LCA results comparison



Conclusions

- Transportation of hydrogen with LOHC causes significant environmental impacts due to the heat demand for dehydration
- Heat for dehydrogenation from burning of hydrogen
- Usage for the excess heat should be considered
- The long transportation distance causes strong environmental impacts due to the direct emissions from the truck and the ship transport

Thank you for your attention!

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